Claims Listing

1. (previously presented) A method of controlling a biological wastewater treatment process, comprising:

A. in at least one treatment tank containing wastewater and having associated therewith at least one device to supply an increasing and decreasing flow of oxygen-containing gas and/or wastewater into the tank, conducting a biological process wherein the need for oxygen in the process repeatedly increases and decreases during the process,

B. supporting the process at least in part by introducing the oxygen-containing gas into the wastewater in the form of bubbles provided in the wastewater by a gas supply system, and causing at least a portion of the oxygen in the bubbles to dissolve in the wastewater and at least a portion of the dissolved oxygen to be consumed by the biological process

1. wherein the oxygen so dissolved may represent an excess or a deficiency relative to the oxygen consumed by the biological process, and

2. wherein at least one gas collection member is positioned to receive offgas representing gas from said bubbles that has not been dissolved into the wastewater;

C. controlling the operation of the biological process with a control system that, as the process operates, exercises continuing control over the process at least partially in response to

1. offgas measurements that are taken by the control system from the offgas collected in the gas collection member and that are correlative with changing amounts of one or more gases in the offgas, and

2. DO data correlative with varying DO levels in the wastewater and/or performance data correlative with varying ability of the gas supply system to transfer oxygen to the wastewater;

D. utilizing said measurements and data to provide, in the control system, control values, which may be components of control values, and which include

1. first control values, comprising requirements control values, that change in response to, while remaining correlative with, the need for oxygen in the process, and

2. second control values, comprising DO control values and/or performance control values that change in response to, while remaining correlative with, respectively, DO levels in the wastewater and/or the varying ability of the gas supply system to transfer oxygen to the wastewater; and

E. deriving, in the control system, utilizing said first and second control values, control signals for adjusting said at least one device.

2. (previously presented) A method of controlling a wastewater treatment process according to claim 1 wherein the control system exercises continuing control over the amount of gas discharged into the tank and repeatedly increases and decreases that amount, during the process, as the need for oxygen varies, and the control signals derived in the control system are based at least in part on offgas measurements, DO data and performance data and are utilized to control the amount of gas discharged into the tank through said gas supply system.

3. (previously presented) A control system for controlling wastewater treatment apparatus that comprises at least one tank to contain and treat wastewater in a biological process, at least one device to supply an increasing and decreasing flow of an oxygen-containing gas into the wastewater to support the process, a gas supply system to introduce the gas into the wastewater as bubbles and cause at least a portion of the oxygen in the bubbles to dissolve in the wastewater and be at least partly consumed by the process and at least one gas collection member positioned to receive offgas from the wastewater; said control system comprising the combination of:

A. at least one gas detector that can take offgas measurements correlative with varying amounts of at least one gas collected in the gas collection member,

B. at least one DO (dissolved oxygen) detector that, when in contact with the wastewater in the tank, can take DO measurements of the DO levels of the wastewater, and

C. at least one controller

1. which contains or has access to code which the controller can utilize with the offgas measurements and DO

measurements to provide, in the control system, varying control values, which may be components of control values, that are

a. at least in part correlative with repeatedly fluctuating requirements for oxygen-containing gas flow to support the biological process and

b. at least in part correlative with such varying positive or negative adjustment of the oxygen-containing gas flow as may be needed to cause the wastewater DO levels to move toward, return to or be maintained at a target value, and

2. which derives control signals, based at least in part on said control values, to which the at least one device is responsive.

4. (previously presented) A control system according to claim 3 wherein the at least one controller contains or has access to additional code which the controller can utilize with performance data to provide, in the control system, varying additional control values, which may be components of control values, correlative with the varying ability of the gas supply system to transfer oxygen to the wastewater, and wherein the additional code is

configured to apply the additional control values in combination with the first-mentioned control values in deriving the control signals.

5. (new) A method of exercising continuing control over an oxygen-consuming biological wastewater treatment process in which the need for oxygen repeatedly increases and decreases and which is conducted in at least one wastewater treatment plant processing tank in cooperation with

a gas supply system to supply oxygen-containing gas bubbles to, and dissolve oxygen in, the wastewater in the at least one plant processing tank and

a control system comprising to

at least one flow control element to supply an increasing and decreasing flow of oxygen-containing gas through the gas supply system into the wastewater in the at least one plant processing tank,

at least one gas collection member and gas detector to provide off-gas data correlative with changing amounts of one or more gases in offgas from the wastewater and

a controller to process the offgas data and cause the flow control element to increase and decrease the flow of oxygen-containing gas into the wastewater in said tank or tanks,

which method comprises:

providing in the control system DO (dissolved oxygen) data correlative with varying DO levels in the wastewater and/or performance data correlative with varying ability of the gas supply system to dissolve oxygen in the wastewater,

generating control values in the control system derived at least in part from (a) the offgas data and (b) the DO data and/or performance data and

using such control values to generate control signals to cause the at least one flow control element to cause varying flows of oxygen-containing gas through the gas supply system and into the at least one processing tank that are correlative with the varying consumption of oxygen by the biological process adjusted to

cause wastewater DO levels to move toward, return to or be maintained at a target value and/or

compensate for the varying ability of the gas supply system to dissolve oxygen in the wastewater.

6. (new) A method according to claim 5 comprising generating control values in the control system derived at least in part from the offgas data, DO data and performance data and using such values to generate control signals to cause the at least one flow control element to provide flows of oxygen-containing gas into the at least one plant processing tank reflecting process oxygen needs adjusted to (a) cause wastewater DO levels to move toward, return to or be maintained at a target value and (b) compensate for the varying ability of the gas supply system to dissolve oxygen in the wastewater.

7. (new) Apparatus for exercising continuing control over an oxygen-consuming biological wastewater treatment process in which the need for oxygen repeatedly increases and decreases and which is conducted in at least one wastewater treatment plant processing tank in cooperation with

a gas supply system to supply oxygen-containing gas bubbles to, and dissolve oxygen in, the wastewater in the at least one plant processing tank, and

a control system comprising

at least one flow control element to supply an increasing and decreasing flow of oxygen-containing gas through the gas supply system into the wastewater in the at least one plant processing tank and

at least one gas collection member and gas detector to provide off-gas data correlative with changing amounts of one or more gases in offgas from the wastewater,

a controller to process the off-gas data and cause the flow control element to increase and decrease the flow of oxygen-containing gas into the wastewater in said tank or tanks,

characterized in that

the apparatus comprises at least one DO (dissolved oxygen) detector to provide, in the control system, DO data reflecting DO levels in the wastewater and

the controller contains or has access to code which, with the aid of the offgas data and DO data, the controller defines varying control values comprising separate or combined

requirements control values correlative with the repeatedly fluctuating need for oxygen-containing gas flow to support the biological process and

DO control values that are correlative with such varying positive or negative adjustments of oxygen-containing gas flow sufficient to cause the wastewater DO levels to move toward, return to or be maintained at a target value.

the at least one flow control element is connected with the controller to receive and act in response to control signals in the control system based at least in part on said control values to supply an increasing and decreasing flow of oxygen-containing gas through the gas supply system into the wastewater in the at least one plant processing tank.

8. (new) Apparatus according to claim 7 wherein the controller contains or has access to code which, with the aid of performance data, the controller defines performance values that are correlative with additional oxygen-containing gas flow adjustments needed to compensate for varying ability of the gas supply system to dissolve oxygen in the wastewater.

9. (new) Method according to claim 1 wherein the biological process comprises suspended growth aeration which includes biological metabolization of suspended and/or dissolved waste material present in the wastewater.

10. (new) Method according to claim 1 wherein the biological process is a continuous flow process.

11. (new) Method according to claim 1 wherein the biological process is an activated sludge process.

12. (new) Method according to claim 1 wherein the control system is programmed to tend to maintain a positive DO level in at least a portion of the tank.

13. (new) Method according to claim 5 wherein the control system is programmed to tend to maintain a positive DO level in at least a portion of the tank.

14. (new) Apparatus according to claim 3 wherein said gas collection member is positioned at a surface of the wastewater.

15. (new) Apparatus according to claim 3 comprising a tank having a wastewater inlet and an outlet, and the control system includes DO measuring devices at first and second locations in the tank.

16. (new) Apparatus according to claim 15 wherein the first location is closer to the inlet than to the second location.

17. (new) Apparatus according to claim 15 wherein the second location is closer to the outlet than to the first location.

18. (new) Apparatus according to claim 15 wherein the first location is closer to the gas collection member than to the second location.

19. (new) Apparatus according to claim 15 wherein the first location is adjacent the inlet and the second location is adjacent the outlet.

20. (new) Apparatus according to claim 15 wherein the gas collection member and the first location are each closer to the inlet than to the second location.

21. (new) Apparatus according to claim 15 wherein the gas collection member and the second location are each closer to the outlet than to the first location.

22. (new) Apparatus according to claim 15 wherein the gas collection member is positioned between the first and second locations.

23. (new) Apparatus according to claim 3 wherein the at least one tank comprises upstream and downstream halves.

24. (new) Apparatus according to claim 3 wherein the at least one tank is divided into at least two sections by a baffle and/or other form of length divider, at least one of said sections having upstream and downstream halves.

25. (new) Apparatus according to claim 3 wherein the gas collection member is positioned in an upstream half of a tank or tank section to receive offgas representing gas from bubbles that have not been dissolved in the wastewater.

26. (new) Apparatus according to claim 7 wherein the gas collection member is positioned in an upstream half of a tank or tank section to receive offgas representing gas from bubbles that have not been dissolved in the wastewater.

27. (new) Apparatus according to claim 25 wherein the control system includes at least two DO probes respectively positioned in upstream and downstream halves of a tank or tank section for gathering data with respect to DO levels.

28. (new) Apparatus according to claim 26 wherein the control system includes at least two DO probes respectively positioned in upstream and downstream halves of a tank or tank section for gathering data with respect to DO levels.

29. (new) Apparatus according to claim 3 comprising a tank or tank section having an upstream end, and at least portions of the gas collection member and of a DO probe are positioned within an interval of about the first 20% of tank length, measured from the upstream end.

30. (new) Apparatus according to claim 7 comprising a tank or tank section having an upstream end, and at least portions of the gas collection

member and of a DO probe are positioned within an interval of about the first 20% of tank length, measured from the upstream end.

31. (new) Method according to claim 1 wherein the controller contains or has access to tables of data, with the aid of which it defines said control values.

32. (new) Method according to claim 5 wherein the controller contains or has access to tables of data, with the aid of which it defines said control values.

33. (new) Method according to claim 1 wherein the control system operates as a feed forward controller wherein control outputs are generated, at least in part, based on requirements control values and performance control values.

34. (new) Method according to claim 5 wherein the control system operates as a feed forward controller wherein control outputs are generated, at least in part, based on requirements control values and performance control values.

35. (new) Method according to claim 1 wherein said control values comprise plural control value components combined within the controller to generate one or more control signals.

36. (new) Method according to claim 5 wherein said control values comprise plural control value components combined within the controller to generate one or more control signals.

37. (new) Method according to claim 35 wherein said control values comprise, as component parts thereof, requirements control values combined with DO control values.

38. (new) Method according to claim 36 wherein said control values comprise, as component parts thereof, requirements control values combined with DO control values.

39. (new) Method according to claim 35 wherein said control values comprise, as component parts thereof, requirements control values combined with DO rate of change values and DO control values.

40. (new) Method according to claim 36 wherein said control values comprise, as component parts thereof, requirements control values combined with DO rate of change values and DO control values.

41. (new) Method according to claim 35 wherein said control values comprise, as component parts thereof, requirements control values combined with performance control values.

42. (new) Method according to claim 36 wherein said control values comprise, as component parts thereof, requirements control values combined with performance control values.

43. (new) Method according to claim 1 comprising providing gas supply system operational performance data in the control system.

44. (new) Method according to claim 1 comprising providing gas supply system performance standard data in the control system.

45. (new) Method according to claim 44 comprising providing gas supply system relative system performance data in the control system that is derived at least in part with performance standard data.

46. (new) Method according to claim 5 wherein DO levels in the wastewater differ positively and/or negatively from a target DO value and the system generates DO control values and control signals which are sufficient, when applied in conjunction with requirements control values

generated by the system, to at least partially offset deviations of the DO levels from the target DO value.

47. (new) Method according to claim 46 wherein the control system generates DO control values and control signals correlative with the amount of oxygen flow required to move the DO level in the wastewater to the target DO value.

48. (new) Method according to claim 1 wherein:

A. the control system establishes, on a continuing basis, control values that are at least in part correlative with a combination of (1) changing consumption of oxygen by the biological process, as measured with the aid of said gas collection member and (2) deviations, from a first target value, of the DO level measured by a DO probe positioned along an upstream portion of the wastewater flow path, and

B. the control system adjusts said first target value, on a continuing basis, with the aid of data correlative with deviations, from a second target value, of the DO level measured by a DO probe positioned along a downstream portion the flow path.

49. (new) Method according to claim 5 wherein:

A. the control system establishes, on a continuing basis, control values that are at least in part correlative with a combination of (1)

changing consumption of oxygen by the biological process, as measured with the aid of said gas collection member and (2) deviations, from a first target value, of the DO level measured by a DO probe positioned along an upstream portion of the wastewater flow path, and

B. the control system adjusts said first target value, on a continuing basis, with the aid of data correlative with deviations, from a second target value, of the DO level measured by a DO probe positioned along a downstream portion the flow path.

50. (new) Method according to claim 1 wherein the wastewater flows along a flow path having a dimension in the direction of wastewater flow that is greater than its average dimension perpendicular to such direction.

51. (new) Method according to claim 1 wherein:

A. data with respect to the rate of change of DO level is gathered from at least one DO probe positioned in the tank, and

B. the control system establishes, on a continuing basis, control values which are applied to the tank as a whole, said control values being at least in part correlative with a combination of (1) changing consumption of oxygen by the biological process, as measured with the aid of the gas collection member along an upstream portion of a wastewater flow path through the tank (2) DO level data gathered from at least two DO

probes respectively positioned along upstream and downstream portions of the flow path and (3) DO rate of change data.

52. (new) Method according to claim 5 wherein:

A. data with respect to the rate of change of DO level is gathered from at least one DO probe positioned in the tank, and

B. the control system establishes, on a continuing basis, control values which are applied to the tank as a whole, said control values being at least in part correlative with a combination of (1) changing consumption of oxygen by the biological process, as measured with the aid of the gas collection member along an upstream portion of a wastewater flow path through the tank (2) DO level data gathered from at least two DO probes respectively positioned along upstream and downstream portions of the flow path and (3) DO rate of change data.

53. (new) Method according to claim 1 comprising generating, in the control system on a continuing basis, relative system performance control values correlative with relationships between

A. operational performance data, generated by the control system, correlative with the varying ability of the gas supply system to transfer oxygen to the wastewater under fluctuating process conditions, comprising one or more of gas supply system conditions, wastewater conditions, process conditions, and atmospheric conditions, and

B. performance standard data, provided in the control system, correlative with the ability of the gas supply system to transfer oxygen to water and/or wastewater under predetermined standards for said conditions.

54. (new) Method according to claim 5 comprising generating, in the control system on a continuing basis, relative system performance control values correlative with relationships between

A. operational performance data, generated by the control system, correlative with the varying ability of the gas supply system to transfer oxygen to the wastewater under fluctuating process conditions, comprising one or more of gas supply system conditions, wastewater conditions, process conditions, and atmospheric conditions, and

B. performance standard data, provided in the control system, correlative with the ability of the gas supply system to transfer oxygen to water and/or wastewater under predetermined standards for said conditions.

55. (new) Method according to claim 5 wherein the control values are established at least in part with operational performance data which is provided in the control system and which is based on at least one of the following: gas supply system conditions, wastewater conditions, process conditions, and atmospheric conditions, and said conditions, including

characteristics of any of the foregoing conditions, are determined by the control system.

56. (new) Method according to claim 1 wherein the control values are established at least in part with performance standard data that includes oxygen transfer rate : flow data correlative with oxygen transfer rates which the gas supply system could achieve in clean water at varying rates of flow of gas through the gas supply system.

57. (new) Method according to claim 5 wherein the control values are established at least in part with performance standard data that includes oxygen transfer rate : flow data correlative with oxygen transfer rates which the gas supply system could achieve in clean water at varying rates of flow of gas through the gas supply system.

58. (new) Method according to claim 1 wherein the control values are established at least in part with apparent alpha values which are correlative with a ratio between (a) the rate, as determined by the system, at which the gas supply system can transfer oxygen to the wastewater and (b) the rate at which the gas supply system can transfer oxygen to clean water.

59. (new) Method according to claim 5 wherein the control values are established at least in part with apparent alpha values which are correlative

with a ratio between (a) the rate, as determined by the system, at which the gas supply system can transfer oxygen to the wastewater and (b) the rate at which the gas supply system can transfer oxygen to clean water.

60. (new) Method according to claim 1 comprising:

A. providing, in the control system, oxygen transfer rate : flow control values correlative with oxygen transfer rates which the gas supply system could achieve in clean water at varying rates of flow of gas through the gas supply system;

B. providing, in the control system, apparent alpha values which are correlative with a ratio between (a) the rate, as determined by the system, at which the gas supply system can transfer oxygen to the wastewater and (b) the rate at which the gas supply system could transfer oxygen to clean water; and

C. deriving relative system performance values by combining oxygen transfer rate : flow and apparent alpha values.

61. (new) Method according to claim 5 comprising:

A. providing, in the control system, oxygen transfer rate : flow control values correlative with oxygen transfer rates which the gas supply system could achieve in clean water at varying rates of flow of gas through the gas supply system;

B. providing, in the control system, apparent alpha values which are correlative with a ratio between (a) the rate, as determined by the system, at which the gas supply system can transfer oxygen to the wastewater and (b) the rate at which the gas supply system could transfer oxygen to clean water; and

C. deriving relative system performance values by combining oxygen transfer rate : flow and apparent alpha values.

62. (new) Method according to claim 1 wherein apparent alpha values are determined at least in part by the control system and reflect changes in the condition of the gas supply system and the wastewater that can affect the amount of oxygen which the gas supply system can transfer to the wastewater.

63. (new) Method according to claim 5 wherein apparent alpha values are determined at least in part by the control system and reflect changes in the condition of the gas supply system and the wastewater that can affect the amount of oxygen which the gas supply system can transfer to the wastewater.

64. (new) Method according to claim 1 wherein control values are applied by the system based at least in part on process control needs comprising (a) process oxygen control needs and (b) DO level control needs and/or

performance control needs, and wherein the applied control value is within plus or minus 20%, based on the data available in the system at the time the applied control value is applied, of a reference control value which would produce a flow rate of gas and/or wastewater into the biological process that would precisely satisfy the particular need or needs.

65. (new) Method according to claim 64 wherein the applied control value is within plus or minus 10% of the reference control value.

66. (new) Method according to claim 64 wherein the applied control value is within plus or minus 5% of the reference control value.

67. (new) Method according to claim 64 wherein the applied control value is within plus or minus 3% of the reference control value.

68. (new) Method according to claim 1 wherein the control system exercises control over the process at least partially in response to said offgas measurements and said DO data and uses said measurements and said data to provide control values which comprise requirements control values and DO control values.

69. (new) Method according to claim 1 wherein the control system exercises control over the process at least partially in response to said

offgas measurements and said performance data and uses said measurements and said data to provide control values which comprise requirements control values and performance control values.

70. (new) Method according to claim 1 wherein the control system exercises control over the process at least partially in response to said offgas measurements, said DO data and said performance data and uses said measurements and said data to provide control values which comprise requirements control values, DO control values and performance control values.

71. (new) Method according to claim 1 wherein the control system exercises continuing control over the amount of gas discharged into the tank and repeatedly increases and decreases that amount, during the process, as the need for oxygen varies, and the control signals derived in the control system are based at least in part on offgas measurements and DO data and are utilized to control the amount of gas discharged into the tank through said gas supply system.

72. (new) Method according to claim 1 wherein the control system exercises continuing control over the amount of gas discharged into the tank and repeatedly increases and decreases that amount, during the process, as the need for oxygen varies, and the control signals derived in

the control system are based at least in part on offgas measurements and performance data and are utilized to control the amount of gas discharged into the tank through said gas supply system.

73. (new) Method according to claim 5 comprising generating control values in the control system derived at least in part from the offgas data and DO data and using such values to generate control signals to cause the at least one flow control element to provide flows of oxygen-containing gas into the at least one plant processing tank reflecting process oxygen needs adjusted to cause wastewater DO levels to move toward, return to or be maintained at a target value.

74. (new) Method according to claim 5 comprising generating control values in the control system derived at least in part from the offgas data and performance data and using such values to generate control signals to cause the at least one flow control element to provide flows of oxygen-containing gas into the at least one plant processing tank reflecting process oxygen needs adjusted to compensate for the varying ability of the gas supply system to dissolve oxygen in the wastewater.

75. (new) Apparatus according to claim 4 comprising code that defines, on a continuing basis, relative system performance control values correlative with relationships between

A. operational performance data correlative with the varying ability of the gas supply system to transfer oxygen to the wastewater under fluctuating process conditions, comprising one or more of gas supply system conditions, wastewater conditions, process conditions, and atmospheric conditions, and

B. performance standard data correlative with the ability of the gas supply system to transfer oxygen to water and/or wastewater.

76. (new) Apparatus according to claim 4 comprising code that defines operational performance data.

77. (new) Apparatus according to claim 4 that includes or has access to performance standard data.

78. (new) Apparatus according to claim 4 comprising code that defines relative system performance data at least in part with performance standard data that is stored in the control system.

79. (new) Apparatus according to claim 4 wherein performance standard data is stored in the system and includes oxygen transfer rate : flow data correlative with oxygen transfer rates which the gas supply system could achieve in clean water at varying rates of flow of gas through the gas supply system.

80. (new) Apparatus according to claim 4 wherein the requirements control values and DO control values are based at least in part on relationships with relative system performance values.